J. Agric. Sci. Mansoura Univ., 30 (7): 3611 - 3624, 2005

THE PRODUCTIVE PERFORMANCE OF LAYING HENS IN HOT ENVIRONMENTS AS AFFECTED BY DIETARY ENERGY AND PROTEIN LEVELS.

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ABSTRACT

An experiment was carried out, during the summer season, in Egypt to study the effect of different dietary energy and protein levels on the productive performance of laying hens under hot environments.

Nine dietary treatments were designed to contain three different levels of metabolizable energy (2600, 2800 and 3000 Kcal ME/Kg) and three different levels of crude protein (15, 17 and 19%). A number of 135 "Bovans Brown" laying hens, 24-weeks-old, were used in a randomized 3×3 factorial design and every dietary treatment was fed to 5 replicate groups of 3 hens each. The experimental diet T_1 was formulated according to feed requirements of "Bovans Brown" to represent the control treatment diet.

At the end of the experiment egg production, egg weight, egg mass, feed consumption and mortality rate were recorded. Energy intake, protein intake, feed conversion ratio and live body weight change were calculated. The economic efficiency of egg production for hens fed the experimental diets was calculated.

The results showed that:

- Mean feed consumption significantly ($P<0.05$) decreased with the increase of dietary energy level. However, no significant differences were detected for feed consumption between treatments due to dietary protein levels (15, 17 and 19%CP).
- Birds fed the dietary energy level of 2800 Kcal ME/Kg and 19% CP recorded the highest energy and protein intake values, while those received 3000 Kcal ME/Kg and 15% CP recorded the corresponding lowest values.
- Live body weight change was not affected by feeding different energy levels. While the highest protein level (19%) significantly ($P<0.05$) increased body weight compared vith the level of 15% CP. However, highest body weight change was attained by hens fed 2800 Kcal ME/Kg and 19% CP.
- The highest egg number or egg production (%) was obtained by birds received 19% CP and 2600 Kcal ME/Kg. While; hens fed diets contained 3000 Kcal ME/Kg and 15%CP recorded the lowest egg production.
- Egg weight and egg mass values reduced as the energy level increased to 3000 Kcal ME/Kg and protein level decreased to 15% with significant difference compared with the other levels of either energy or protein.
- The diet contained 3000 Kcal ME/Kg, and 15% CP recorded significantly ($P<0.05$) the worst feed conversion ratio (FCR) value (2.80) while diets contained either 2600 or 2800 Kcal ME/Kg, each with 19% CP recorded better FCR value that did not significantly differ ($P>0.05$) compared to the control (2800 Kcal ME/Kg, with 17% CP).
- Neither dietary energy nor protein levels affected mortality rate.
- The control treatment (containing 2800 Kcal ME/Kg and 17% CP) had recorded the highest value of economic efficiency, which also surpassed all other treatments.

Treatment (3) which received 2800 Kcal ME/Kg and 19% protein, recorded the highest total feed cost.

Generally, it could be concluded that:

Under hot envirônmental conditions, laying hens fed diets containing 2600 Kcal ME/Kg and 19%CP recorded the highest egg number/hen but with high total feed cost. While those fed diet containing 2800 Kcal ME/Kg and 17%CP recorded the best economic efficiency value. However, each project should have its special calculations considering the important factors affecting its economics that are mainly related to market mechanism and raw materials prices (feed cost).

INTRODUCTION

The term "heat stress" is often used to define the bird's response to wormier environments where some different or abnormal physiological response, such as panting, is occurred (Leeson, 1986). The negative influence of high ambient temperature on the performance of laying hens is well documented (Leeson 1986). Temperature normally exerts its effect on production by influencing food and /or nutrients intake rather than by changing nutrients requirements, although a direct effect of temperature on growth and /or egg mass output may change nutrient requirements (Sauveur and Picard, 1987).

Stilborn *et al.* (1988) indicated that feed consumption of laying hens decreased significantly under high environmental temperature. Also dietary energy concentration is a major factor influenced feed intake (Yamamoto and Brobeck, 1965, NRC, 1994, Yalcin *et al.*, 2001 and Al-Harthi *et al.*, 2002). Scott and Balnave (1988) mentioned that although it is possible by decreasing the ME concentration of the diet to increase the intake of other nutrients, the response is partly offset by the fact that food intake does not increase sufficiently to maintain similar intakes of energy. This appears to be most important at hot environmental where energy intake is limited by reduced appetite.

Morris (2004) reported that feed intake shows a curvilinear dependence on environmental temperature. At temperature below the panting threshold, performance can be maintained by adjusting the feed so as to maintain an adequate intake of critical amino acids. Above the panting threshold, the hen is unable to take in enough energy to maintain normal output.

The requirement of laying hen for protein does not remain constant as a percent of the diet. The hen will vary its intake of food and subsequently of protein depending on its requirement for energy. Level of egg production is also a factor that should be considered (Attia, 1986). Number of reports has shown that improving protein intake by increasing dietary protein concentration only partially overcomes the adverse effect of high temperature on egg output (Reid and Weber, 1975, El-Jack and Blum, 1978). On the other hand, feed cost generally increases with increasing energy and protein levels. Therefore, it is necessary to measure the response of laying hens to different dietary energy and protein levels during hot weather.

This study aimed to compare the performance of laying hens fed different dietary energy and protein levels under hot environmental conditions, in Egypt.

MATERIALS AND METHODS

This experiment was carried out at Fac. Agric. Farm, Cairo Univ., under hot environmental conditions where the maximum temperature ranged from 30 to 42°C.

A total number of 135 "Bovans Brown", 24-wks old laying hens were individually weighed and randomly distributed into the experimental treatments. A randomized 3×3 factorial design was used with 5 replicate groups of 3 hens each, fed one of the experimental diets (Table 1). The nine dietary treatments were designed to contain three different levels of metabolizable energy versus three different levels of crude protein as follows:

		Energy (Kcal ME/Kg diet)		
		2800	2600	3000
CP (%)	17	T_1	T_4	T_7
	15	T_2	T_5	T_8
	19	T_3	T_6	T_9

The experimental diet T_1 was formulated according to feed requirements of "Bovans Brown" to represent the control treatment diet. This study was started from 24-weeks old and lasted to 48-weeks-old. Data of egg production, egg weight, egg mass, feed consumption and mortality rate were recorded. Energy intake, protein intake, feed conversion ratio and live body weight change were calculated.

The chemical analyses of the experimental diets and excreta were undertaken according to the methods of A.O.A.C. (1990). The economic efficiency of treatments was calculated, based upon the difference between the price of egg mass and feeding costs.

Data were statistically analyzed for ANOVA as 3x3 factorial arrangements using the linear model (SX, 1992). Significant differences among means were separated by Duncan's new multiple range test (Duncan, 1955) with 5% level of probability.

RESULTS AND DISCUSSION

Table (2) shows the effect of dietary energy and protein levels on egg number, egg production %, egg weight and egg mass.

Egg number:

The lowest egg number (94.22 egg/hen) was recorded by T_8 (15% CP and 3000 Kcal ME/Kg feed) and significantly differed ($P<0.05$) with the other experimental treatments, while, the highest total egg number/hen was obtained by T_6 (19% CP and 2600 Kcal ME/Kg). Statistical analysis (Table 4) revealed that there was significant difference (P<0.05) between energy level of 3000 Kcal ME /Kg and the other two dietary energy levels (2600 and 2800 Kcal ME/Kg). Also there was significant difference (P<0.05) between protein level of 15% from one hand and 17 or 19% from the other hand.

These results are in agreement with those obtained by Vohra *et al.* (1979) who found that high dietary energy did not improve egg production under high environmental temperature. Pray and Gessel (1961) suggested that egg output can be obtained at temperature up to 30°C by adjusting the composition of the diet so as to maintain an adequate protein intake.

Table (1): The composition and calculated analysis of the experimental diets.

Ingredients	Treatments								
	1	2	3	4	5	6	7	8	9
Yellow corn	66.35	68.85	62.13	58.12	61.12	54.73	71.78	75.00	68.11
Soybean meal (48)	14.05	8.76	19.70	13.77	13.75	19.13	2.80	2.45	3.66
Corn gluten meal	2.43	3.35	4.56	1.03	-	1.67	11.22	10.28	13.48
Wheat bran	3.08	5.77	1.40	12.86	12.94	10.77	0.26	-	-
Meat meal (60%)	3.51	1.9	-	3.17	-	2.40	2.03	-	2.80
Fish meal (72%)	0.56	1.00	1.50	1.10	1.50	1.20	1.50	1.10	1.55
Di-cal. phosphate	1.64	1.83	2.00	1.57	1.98	1.63	1.44	2.15	1.72
Limestone	7.68	7.83	8.00	7.68	8.00	7.75	8.06	8.06	7.74
NaCl	0.33	0.33	0.35	0.33	0.35	0.33	0.33	0.37	0.33
DL.methionine	0.07	0.03	0.06	0.07	0.06	0.09	-	-	-
Lysine HCl	-	0.05	-	-	-	-	0.28	0.29	0.31
Vit. & Min. mix. *	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total	100	100	100	100	100	100	100	100	100
Chemical composition **:									
Crude protein %	17.01	15.02	19	17.02	15.01	19.02	17.02	15.00	19.01
ME (Kcal/Kg)	2800	2800	2800	2602	2601	2601	3000	3000	3000
Calcium %	3.52	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Av. phosphorus %	0.5	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Methionine %	0.36	0.31	0.41	0.36	0.32	0.41	0.36	0.33	0.40
Met. + Cys. %	0.66	0.58	0.73	0.65	0.58	0.73	0.67	0.60	0.73
Lysine %	0.77	0.66	0.88	0.80	0.73	0.93	0.75	0.66	0.84

***Each 3 Kg. contains :Vit.A 10,000,000 IU; Vit.D_3 1,000,000 ICU; Vit.E 10g; Vit.K 1g; Vit.B_1 1g; Vit.B_2 4g; Vit.B_6 1.5g; Vit.B_{12} 10mg; Niacin 20g; Pantothenic acid 10g; Folic acid 1g; Biotin 50mg; Choline chloride (50%) 500g; Iron 30g; Iodine 300mg; Zinc 45g; Manganese 40g; Copper 3g.**

****According to Tables of NRC (1984) and INRA (1986).**

Egg production %:

The results of egg production followed the same trend values of egg number. The lowest (P<0.05) egg production was recorded by birds fed diet containing 15% CP and 3000 Kcal ME/Kg, while the highest total egg production/hen was obtained for birds fed diet containing 19% CP and 2600 Kcal ME/Kg. The main effects revealed that the dietary energy level of 3000 Kcal ME/Kg and CP level of 15%, gave significant (P<0.05) less egg production than the other energy and protein levels.

Table 2. Effect of energy and protein levels on egg number, egg production (%), egg weight and egg mass at the end of the experimental period.

Treatments		Item			
ME level (Kcal/kg)	CP level (%)	Hen-day egg Number (eggs / hen)	Hen-day egg production (%)	Egg weight (g / egg)	Egg mass (kg eggs / hen)
2800	17	137.65 ab	81.92 ab	60.32 ab	8.303 ab
	15	126.93 bc	75.56 bc	58.27 bc	7.396 cd
	19	142.50 a	84.83 a	61.12 a	8.710 a
2600	17	137.52 ab	81 86 ab	60.86 a	8.369 ab
	15	132.13 ab	78.66 ab	58.23 bc	7.649 bc
	19	143.88 a	85.65 a	58.78 abc	8.457 ab
3000	17	124.52 bc	74.12 bc	56.98 c	7.095 cd
	15	94.22 d	56.30 d	56.57 c	5.330 e
	19	112.46 c	66.95 c	59.01 abc	6.636 d
SEM		7.20	4.29	1.25	0.39
Main factors:					
ME level (kcal/kg)	2800	135.69 a	80.77 a	59.90 a	8.14 a
	2600	137.84 a	82.05 a	59.30 a	8.16 a
	3000	110.40 b	65.78 b	57.52 b	6.35 b
CP %	17	133.23 a	79.30 a	59.39 a	7.92 a
	15	117.76 b	70.17 b	57.69 b	6.80 b
	19	132.95 a	79.14 a	59.64 a	7.92 a
SEM		4.16	2.48	0.72	0.23
ME x CP		NS	NS	NS	NS

a, b .... means with different superscript(s)in the same column are significantly different (P < 0.05).

*Standard error mean for comparison.

Egg weight:

Mean egg weight recorded higher (P<0.05) value for birds fed 17% CP and 2800 Kcal ME/Kg, than those fed 17% CP and 3000 Kcal ME/Kg or 15% CP and 3000 Kcal ME/Kg. The highest level of ME (3000 Kcal ME/Kg) or the lowest CP (15%) showed significant (P<0.05) reduction in egg weight value.

As for high energy level (3000 Kcal ME/Kg), the low feed intake recorded with such energy level (Table 3) perhaps affected egg weight value.

These results are in agreement with those obtained by Olomu and Offiong (1983) and Shukla *et al.* (1988) who found that dietary protein level ranging from 16-20% had no significant effect on egg weight. Other investigators indicated that egg weight increased with feeding higher protein level. Ghawla *et al.* (1976) found that protein requirements of " White Leghorn "pullets may be 19% in the summer season.

Moreover, De Andrade *et al.* (1976) found that high nutrient density increase egg weight. Valencia *et al.* (1980) found that egg weight was increased with feeding higher protein level (12 *vs.* 20%). Also, Scott and Balnave (1988) suggested that the increase in protein intake gave a significantly improvement in egg mass output.

and average body weight will be reduced. It is well known that the relationship between environmental temperature and energy intake is curvilinear with food intake declining more steeply as ambient temperature approaches body temperature (Marsden and Morris, 1987). As listed in this study, increasing energy concentration of the diet from 2600 to 2800 Kcal ME/Kg tended to increase (with no significant difference) body weight change and this was more pronounced in the hot environments. While, the more increase of energy concentration in the diet to 3000 Kcal ME/Kg failed to increase body weight change particularly in the hot environments. The results obtained showed also that birds fed diets providing 3000 Kcal ME/Kg and 15% CP were smaller than those fed diets providing 2800 Kcal ME/Kg and 19% CP. It appears that pullet growth is initially more sensitive to dietary protein level, whereas energy intake becomes more critical as the bird approaches maturity. These findings are in agreement with those obtained by Leeson and Summers (1989) with "Leghorn" pullets. Accordingly, it could be stated that the effects of temperature on the performance of laying hens are closely related to its effect on their energy metabolism.

The results showed also the depression in laying hen performance including egg production percentage, egg weight and egg mass particularly in the hot environmental conditions as a result of the depression in feed intake. In this connection, the effect of ambient temperature on egg weight has been reviewed by various investigators (Miller and Sunde, 1975; Lillie *et al.*, 1976; De Andrade *et al.*, 1977 and Vohra *et al.*, 1979). They concluded that sudden or gradual exposure of layers to high environmental temperature, either constant or cyclic, significantly decreased egg weight.

Generally, the best laying hen performance was obtained by feeding diet providing 2600 Kcal ME/Kg and 19% CP, and no significant differences had been detected either between ME levels of 2600 and 2800 or CP levels of 17 and 19%. While, the worst laying hen performance was found by hens which received 3000 Kcal ME/Kg and 15% CP. However, all parameters measured, except few cases, had been improved by the reduction in environmental temperature and humidity or nearly at the end of the experiment.

Generally, it could be concluded from these results that:

- Diet contained 2800 Kcal ME/Kg and 17% CP (control treatment) gave the best economic efficiency value.
- Feeding diet contained 2600 Kcal ME/Kg and 19% CP recorded the highest egg number/hen but with high total feed cost/hen.

Feed cost, which represents about 60-65% of the total costs of poultry production operation, is an important factor affecting economics of the project. However, each project should have its special calculations considering the important factors affecting its economics, which are mainly related to market mechanism and raw materials prices (feed cost).

In such cases, it can be recommended that insulated buildings with evaporative cooling are necessary in hot climates for optimum egg and meat production.

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الأداء الإنتاجي للدجاج البياض تحت الظروف البيئية الحارة وتأثره بمستوى الطاقة والبروتين فى الغذاء.

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أجريت تجربة خلال فصل الصيف لدراسة تأثير المستويات المختلفة من طاقة وبروتين العليقة على الأداء الإنتاجي للدجاج البياض تحت الظروف الجوية الحارة في جمهورية مصر العربية.

تم إستخدام ١٣٥ دجاجة بياضه من نوع "Bovans Brown" عمر ٢٤ أسبوعا. ووزعت عشوائيا إلي ٩ معاملات في تصميم متداخل ٣×٣ وبكل معاملة (٥ مكررات وبكل مكرر ٣ دجاجات، استخدم في التجربة ٣ مستويات من الطاقة الفسيولوجية النافعة(٢٦٠٠ ، ٢٨٠٠ ، ٣٠٠٠ ك.كالورى/ كجم) كل منها مقابل ٣ مستويات من البروتين الخام (١٥، ١٧، ١٩%) . تم تكوين عليقة المعاملة (١) على حسب الاحتياجات المذكورة لسلالة "Bovans Brown" البياضة لتمثل عليقة المقارنة. بدأت التجربة من عمر ٢٤ أسبوعا وانتهت عند عمر ٤٨ أسبوعا .

تم أخذ القياسات التالية: إنتاج البيض، وزن البيضة، كتلة البيض ،كمية الغذاء المستهلك، نسبة النفوق . تم حساب كمية الطاقة المأكولة، كمية البروتين المأكول ، معامل التحويل الغذائي، التغير في وزن الجسم، فضلا عن حساب الكفاءة الإقتصادية لإنتاج البيض.

يمكن تلخيص النتائج المتحصل عليها من التجربة فيما يلي :

- انخفض متوسط استهلاك الغذاء-معنويا-مع زيادة مستوى الطاقة في العليقة.ولم تظهر فروق معنوية بين المعاملات بالنسبة لاستهلاك الغذاء يمكن أن تعزى إلى مستوى البروتين الخام في العليقة (١٥، ١٧، ١٩%).
- سجلت الطيور التي تغذت على مستوى الطاقة ٢٨٠٠ك كالورى/كجم ، ١٩% بروتين خام أعلى كمية مستهلكة من الطاقة والبروتين. أما المعاملات التي احتوت على ٣٠٠٠ك كالورى/ كجم ، ١٥% بروتين فقد سجلت أقل هذه القيم.
- لم يتأثر التغير في وزن الجسم باختلاف مستوى الطاقة في العليقة. بينما أدى أعلى مستوى بروتين خام (١٩%) إلى زيادة معنوية في وزن الجسم عن مستوى البروتين الخام ١٥% . وقد سجل أعلى معدل للتغير فى وزن الجسم بالتغذية على عليقة تحتوى على ٢٨٠٠ك كالورى/كجم ، ١٩% بروتين خام.
- سجلت المعاملة التي تحتوي على ١٩% بروتين خام، ٢٦٠٠ك كالورى/كجم-أعلى عدد بيض وأعلى نسبة مئوية للبيض المنتج-وكان أقل إنتاج بيض للمعاملة التي تحتوي على ١٥% بروتين ٣٠٠٠ ك كالورى/كجم عليقة.
- انخفض وزن البيضة وكتلة البيض مع مستوى الطاقة ٣٠٠٠ ك كالورى/ كجم عليقة أو مستوى بروتين ١٥%. وكان الاختلاف معنوياً مع مستويات الطاقة والبروتين الأخرى.
- سجلت العليقة المحتوية على مستوى الطاقة ٣٠٠٠ك كالورى/كجم ، ١٥% بروتين خام أسوأ معامل تحويل غذائي (٢,٨٠). بينما سجلت العلائق المحتوية على مستوى الطاقة ٢٨٠٠ أو٢٦٠٠ ك.كالورى/كجم مع ١٩% بروتين خام قيما لمعامل التحويل الغذائي لم تختلف معنويا عن مثيلتها فى عليقة المقارنة (٢٨٠٠ ك.كالورى/كجم مع ١٧% بروتين خام).
- لم تؤثر مستويات البروتين الخام أو الطاقة الفسيولوجية النافعة المستخدمة في هذه الدراسة على معدل النفوق.
- كانت أفضل كفاءة الإقتصادية لإنتاج البيض لعليقة المقارنة والتي احتوت على ٢٨٠٠ك كالورى/كجم ، ١٧% بروتين خام وكانت أعلى تكلفة تغذية للمعاملة (٣) التي احتوت على ٢٨٠٠ك كالورى/كجم ، ١٩% بروتين خام .

وعلى ذلك ، يمكن أن نخلص-من النتائج السابقة-إلى أنه:

تحت الظروف الجوية الحارة-كان أفضل معدل إنتاج بيض بالتغذية على عليقة تحتوى على ٢٦٠٠ ك كالورى طاقة فسيولوجية نافعة / كجم ، ١٩% بروتين خام ، ولكن مع ارتفاع تكاليف التغذية. بينما كانت أفضل النتائج الاقتصادية بإستخدام عليقة تحتوى على ٢٨٠٠ك كالورى طاقة فسيولوجية نافعة/ كجم، ١٧% بروتين خام.